
Uri Kartoun PhD$^{1,2}$, Kathleen E Corey MD MPH MMSc$^{2,3}$, Hui Zheng PhD$^4$, Stanley Y Shaw MD PhD$^{1,2}$

1. Center for Systems Biology; Center for Assessment Technology & Continuous Health (CATCH), Massachusetts General Hospital, Boston, MA.  
2. Harvard Medical School, Boston, MA.  
3. Gastrointestinal Unit, Massachusetts General Hospital, Boston, MA.  
4. Center for Biostatistics, Massachusetts General Hospital, Boston, MA.

**Summary:** Hospitalizations among individuals with cirrhosis are frequent. Accurate assessment of the risk of mortality following cirrhosis-related admissions can enable clinicians to identify high-risk patients and modify treatment plans to decrease mortality risk.

**Methods:** 314,292 patients who received care at two urban tertiary care hospitals between 1992 and 2010 were included. Individuals with cirrhosis were identified using a combination of billing codes and mentions of “cirrhosis” in discharge summaries. We developed a prediction model for 90-day mortality considering patients who survived a cirrhosis-related admission. We extracted 113 Electronic Medical Record (EMR) structured and unstructured variables including demographics, laboratory values, billing codes, medications, and liver-related concepts from clinical narrative notes. We calculated areas under the receiver operating characteristic curves (AUROCs) to measure model accuracy in derivation and validation sets. To select the most informative variables, we used logistic regression with the adaptive least absolute shrinkage and selection operator (LASSO).

**Results:** We identified 4,781 cirrhosis-related admissions in which all patients survived the admission. 778 of the admissions resulted in death within 90 days after discharge (16.2%). Twenty seven variables were predictors of 90-day mortality (Figure 1). These included the Model for End-Stage Liver Disease (MELD) score, white blood cell count, total bilirubin, hepatorenal syndrome, steatohepatitis, dyslipidemia, ascites, and hepatocellular carcinoma. Using a cross validation scheme yielded AUROCs of 0.82 for the derivation and 0.79 for the validation sets. In contrast, the MELD score alone yielded a lower AUROC of 0.69. When the MELD score was excluded from the original model the AUROC remained superior to MELD alone with an AUROC of 0.79. In addition, when MELD and all components of MELD were excluded the model was again superior to MELD alone with an AUROC of 0.77. The AUROCs are presented in Figure 2.

**Discussion:** The cirrhosis mortality prediction model can be used to identify patients at high risk for mortality after surviving an admission related to cirrhosis. Further, we demonstrate that our model is superior to the MELD score alone. This finding demonstrates that use of an unbiased approach can identify unique predictors of death in those with cirrhosis. The MELD score has extensively been adopted to predict patient outcomes and is associated with increased mortality and re-admission rates in individuals with cirrhosis. We demonstrate, however, that the contribution of the MELD score to improve model accuracy considering a large set of cirrhosis-related admissions is minimal when accompanied by twenty-six additional EMR variables selected by the adaptive LASSO feature selection algorithm. These findings suggest that there is a need to develop new types of cirrhosis-related indexes to predict outcomes that rely more extensively on EMR.
Figure 1. Variables selected: 90-day mortality prediction. HR = Hazard ratio; CI = confidence interval; S = Structured; U = Unstructured.

Figure 2. AUROCs using varying combinations of variables.